Presented to:

NASA TEERM Symposium

Army Aviation and Missiles Approach to Lead-free Management

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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EU RoHS Impact

There is a global shift to Pb-free electronics accelerated by EU legislation effective 1 Jul 06

- **Programs need to develop and implement a Pb-free transition management approach**
  - **This does not mean that programs should transition to Pb-free!**
    - **Must manage the risk induced on the supply chain**
  - **Tin Whisker risk**
    - **Industry tests do not sufficiently address military applications**
  - **Reliability assessment**
  - **Life cycle support (repair, changing materials management)**

Industry LEAP standards provide framework

- **Awareness within entire supply chain needed**
- **Pb-free research support and coordination still required to manage transition risk**

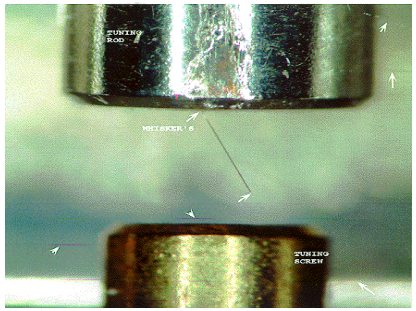
Pb-free: Primary Concerns

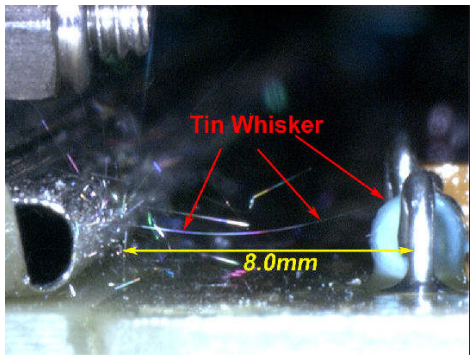
Part Finish

- SnPb Baseline
  - ❑ Provides excellent solderability when stored properly
- Pb-free alternatives generally provide good solderability, BUT …
  - ❑ Pure tin and high tin (>96% without Pb) plating forms conductive whiskers
    - http://nepp.nasa.gov/whisker/
  - ❑ Poor solderability after storage for some finishes
    - Examples: ENIG, immersion silver
- Pure/high tin usage increasing: requires supply chain management

Solder Joints

- Reliability characterization of Pb-free alloys not complete
  - ❑ Many alloy types being developed and used
  - ❑ Temperature cycling and aging effects are complex
- Pb contamination can decrease reliability of some Pb-free systems
  - ❑ Bi alloys have potential for drastic effect
  - ❑ Some alloys have improved reliability with Pb added
- Incompatible reflow temperatures for "mixed" assemblies





ENIG: Electroless Nickel Immersion Gold

Pb-free Management

- Tin Whisker Risk Mitigation
  - Proactive countermeasures for entry into production required
  - Application considerations
    - Effective conformal coat on conductors
      - Parylene best, urethane probably workable, acrylic risky
      - New materials in development
    - Spacing between conductors, particularly those uncoated
      - Consider shorting effect (50 mA fusing, single event upset)
    - Potential for impact of tin whisker debris
  - Test and Evaluation
    - No credible criteria for long-term applications
    - Multiple environments need to be considered for risk mitigation testing
    - Hardware repair should include whisker inspection
- Pb-free Solder Assemblies
  - Qualification test approaches still under development
    - GEIA-STD-0005-3 out for ballot; initial version does not have all details
  - Recommend avoiding at this time
  - Risk mitigation tests need to include aging precondition, longer dwell time in temp cycle than SnPb, vibration/shock test in series with aging/temp cycle

Recommendations for Programs

- Become familiar with Pb-free Issues (GEIA-HDBK-0005-1 and -2)
- Develop and Implement Transition Plan
  - Require prime contractor plan (GEIA-STD-0005-1)
    - Tin Whisker risk management plan needed (GEIA-STD-0005-2), usually level 2C
      - Multiple mitigation techniques necessary – effective conformal coat preferred
  - Flow-down requirement to part level (review COTS items)
- Parts
  - Assure that devices do not have pure/high tin plating
    - Use SnPb or NiPdAu finish (SAC array balls need higher reflow temperature)
      - Significant availability of SnPb finish and growing NiPdAu use
      - SAC ball whisker risk not adequately characterized yet
    - Assure that proper ordering codes are used
  - Refinish parts where risk of whiskers makes it appropriate
    - Don't impose refinish risk of damage where benefit not significant
  - Avoid devices with Bi
    - Uncertain effects of low Bi doping with Pb
- Solder Assembly and Repair/Rework
  - Continue using SnPb solder
  - Assure compatibility of all materials and processes
    - Reflow temperatures, intermetallic compounds, etc.
  - Only use Pb-free after proper training, process development, and application qualification
- Pb-free Solder Process Development
  - Understand solder properties, impact on processes, inspections
  - Qualify process/design for application requirements (reliability)

AMRDEC/Army Pb-free Efforts

- Pb-free Evaluation Project
  - Lead-free Solders: initial focus on material properties
  - Tin Whiskers: focus on actual parts, life cycle environments, coatings
  - Leverage existing work (LEAP, Auburn CAVE, etc.), LEAP/ELF roadmaps
- Industrial Base Innovation Fund
  - Lead-free solder material characterization project approved by DUSD(IP)
  - Reliability Information Analysis Center contract
- Congressional thru Army SMDC
  - AERI Team: Radiance Tech., Rosebud Sioux Tribe, SD Mines/Technology
  - Lead-free support and development in their Charter
  - Coordinate activities to complement Gov/Ind efforts
  - Conformal Coating study being defined; other ideas in progress
  - AERI interested in Prime Contractor mentor
- Depot (and other) Collaboration
  - X-ray Fluorescence Demo and round robin, data sharing
  - Generating Depot guidance
  - Tri-Service Coordination (e.g., tech manuals)
- Citing GEIA standards in Contract Requirements

AMRDEC Lead-Free Management

Basic SOW Requirements:

- The Contractor shall prepare and deliver a Lead-Free (Pb-free) Management Plan IAW DI-MISC-80508 (XXXX). The plan shall address solders and finishes in the delivered aircraft. The Contractor shall implement the plan, as approved by the Government, to manage the effects of the electronics supply chain Pb-free transition, IAW GEIA-STD-0005-1, and the use and effects of pure tin (tin finishes with <3% Pb) IAW GEIA-STD-0005-2, level 2C.
- Also, leveraging MIL-STD-3018 and its DID

Tin Whisker Risk Assessment:

- Design approach should include upfront consideration of finishes part selection
  - Easy to design-in pure tin if it's not considered at initial selection
  - Consider availability and cost of obtaining no-risk finish if different finishes on same part available
- Consider factors that influence whisker shorting risk
  - Barrier: Parylene>urethane>acrylic
    - Coverage consistency and robustness
  - Spacing: 1250 um for minimal risk
  - Finish properties: Underplate, anneal, alloying
- Consider risk of refinishing